# DIOXIN LEVELS IN VIETNAMESE FOOD EXPORTED TO THE USA AND LAOS AND IN LAOTIAN FOOD PURCHASED IN LAOS IN 2001

Arnold Schecter[1], Marian Pavuk[1], Rainer Malisch[2], Jake Ryan[3]

[1]University of Texas-Houston School of Public Health, Dallas Campus: 5323 Harry Hines Blvd., V8.112, Dallas, TX 75390, USA; arnold.schecter@utsouthwestern.edu
[2]State Laboratory for Chemical and Veterinary Analysis of Food (CVUA), Bissierstrasse 5, D-79114 Freiburg, Germany
[3]Bureau of Chemical Safety, Health Canada, Banting 2203D, Ottawa, Ontario K1A OL2, Canada

## Introduction

Vietnam, Cambodia and Laos were sprayed with Agent Orange during the US-Vietnam war between 1962 and 1971. Agent Orange was contaminated with 2,3,7,8-TCDD.[1] Spraying was confined to the south of Vietnam, about 10 to 20% of which was sprayed. Smaller areas along the Ho Chi Minh Trail were also sprayed in Laos and Cambodia. Very elevated levels of TCDD were found in 1970 and 1973 in Vietnamese food and human milk samples: up to 810 parts per trillion (ppt or pg/g) in fish, and up to 1,832 ppt in human milk lipid, collected in Agent Orange sprayed villages.[2-4] Our previous studies of human and food samples from Cambodia did not find elevated TCDD in any specimens, despite an attempt to reach Agent Orange sprayed areas.[5-6] The Vietnamese government does not, at this time, allow food to be taken from Vietnam for dioxin analysis. For that reason, we purchased Vietnamese food exported to the United States and some exported to Laos.

## Methods

Exported Vietnamese fish samples were purchased in 2001 in Dallas, Texas, and in Los Angeles, California. These cities were chosen because they have large Vietnamese populations. Laotian fish and other food samples were purchased in Sepone and Vientiane markets in Laos. Three food samples bought in Laos were of Vietnam origin (chicken eggs, Vietnam dried fish and fish paste). Chemical analyses for dioxins, dibenzofurans and dioxin like PCB congeners were performed by German and Canadian laboratories (CVUA, Freiburg and Health Canada, Ottawa) using high resolution gas chromatography-high resolution mass spectrometry.[7-8] "Total PCDD" and "Total PCDF" refer to the sum of 2,3,7,8-substituted dibenzodioxin and dibenzofuran congeners, only. "Total co-PCB" is the sum of non-ortho (coplanar) PCB congeners 77, 81, 126 and 169. Results for other PCB congeners (mono-ortho contributing to TEQ or di-ortho used as "marker" or "indicator") analyzed by the CVUA Freiburg laboratory are not presented in this abstract and not included in the TEQ calculations for this paper. Both laboratories have been qualified through numerous interlaboratory studies for analysis of dioxins and dioxin-like PCBs in human tissues and food and are certified by the World Health Organization (WHO).

## Results

Levels in Vietnamese food are low compared to recent data for US fish and other food. Table 1 shows dioxin, dibenzofuran, and dioxin like PCB data where available. Fat content varies from 0.3 to 20 % in "edible" portions (flesh) of the food. TCDD is from 0.001 to 0.68 ppt. Total WHO PCDD/F TEQ varies from 0.003 to 0.453 ppt. Total PCDD/F/PCB toxicity varies from 0.003 to 0.736. Table 1 also shows similar findings in US fish.[9] In different types of German fish, the range found in 138 samples analyzed between 1993 and 1996 varied from 0.003 to 7.76 pg PCDD/F I-TEQ/g wet weight (salt-water fish: mean 0.17, trout: mean 0.33, artifical lake fish: mean 0.70, River Rhine fish: 1.51).[10-11] Updated results for 276 fish samples analyzed between 1994 and 2000 at the CVUA were between <

0.01 pg and 11 pg PCDD/F I-TEQ/g wet weight (including fish from the River Rhine; maximum without fish from the River Rhine: 3.52 pg I-TEQ/g wet weight).

Table 2 shows Laotian food purchased in Laos, from sprayed Sepone District Center and Village, and a non-sprayed area, Vientiane. Lipid percent in flesh varied from 0.5 to 41.9 % in fish and other food items with two fish fat samples (carp and catfish) having fat percent of 53.7 and 84.4. Considering these two samples separately, TCDD levels in the rest of the fish and food samples vary from 0.001 to 0.329 ppt. PCDD/F total dioxin toxic equivalents vary from 0.002 to 0.735 and PCDD/F/PCB dioxin toxic equivalents from 0.009 to 0.851 ppt. In recent US food samples, PCDD/F/PCB dioxin toxic equivalents were 0.397 ppt for beef, 0.334 ppt for chicken, 0.392 ppt for pork and 0.343 ppt for eggs (not shown in Table 2).[12] In the two fish fat samples TCDD levels were 0.475 and 2.433 ppt and total PCDD/F/PCB TEQ were 1.902 and 9.025 ppt. The PCDD/F or PCB levels in fish (and other food) are strongly dependent on the fat content of the fish that varies considerably by species. Because of the accumulation of PCDD/PCDF in adipose tissue, these different fat amounts can lead to different dioxin levels when normalized to wet weight. In addition, the eating habits of fish (e.g. predatory fish, bottom dwelling fish, or others) are important. Therefore, a higher variation of observed PCDD/F levels in different sorts of fish is to be expected compared to other food with more constant fat contents, such as whole milk or chicken eggs.

**Discussion**

Most samples analyzed from sprayed Sepone and a non-sprayed area of Laos, Vientiane, and in food exported from Vietnam to the USA have low TCDD levels. Those with higher TCDD levels also have elevated levels of other congeners. Thus, there is no indication from the congener pattern that Agent Orange produced elevated TCDD levels, at least in the relatively small number of samples analyzed. These low levels are in contrast with elevated dioxin levels in people and the environment in heavily sprayed areas of Vietnam, such as Bien Hoa City, 35 km north of Ho Chi Minh City, formerly Saigon.[13-14] This city had an airbase used for Agent Orange flights and also had a spill of thousands of gallons of Agent Orange in 1970. We recently reported elevated levels of dioxins in 95 % of people sampled in this city. General population levels in non-exposed areas, were approximately 2.2 ppt , but in Bien Hoa City, elevations up to 413 ppt TCDD in blood were found. The highest reported food TCDD levels, reported by Baughman from contaminated fish, were 810 ppt from an area where breast milk levels were up to 1,832 ppt in Tan Uyen or Can Gio villages during the early 1970s.[2-4]

**Acknowledgements**

We thank Dr. Raphael Warshaw for collecting Vietnamese food samples in California; the CS Fund, Warsh-Mott Legacy, the Albert Kundstadter Family Foundation, and the Zumwelt Institute for Public Health and Environmental Medicine for funding this work. We also thank Jacquelyn Chagnon and Roger Rumpf who provided invaluable knowledge of Laos.

**References**

1. Institute of Medicine (IOM). (1994) Committee to Review the Health Effects in Vietnam Veterans of Exposure to Herbicides. Veterans and Agent Orange. Washington, DC: National Academy Press, ISBN 0-309-04887-7.
2. Baughman RW and Messelson M. (1973) An analytic method for detecting TCDD (dioxin) levels of TCDD in samples from Vietnam. Environ Health Perspect 9, 27-35.
3. Baughman RW. (1974) Tetrachlorodibenzo-p-dioxins in the environment: high-resolution mass spectrometry at the picogram level. (Thesis-Biological Sciences). Boston (MA): Harvard Univ.
4. Schecter AJ, Dai LC, Thuy LTB, Quynh HT, Minh DQ Cau HD, Phiet PH, Phuong NT, Constable JD, Baughman R, Päpke O, Ryan JJ, Fürst P, and S. Raisanen. (1995) Agent Orange and the Vietnamese: the persistence of elevated dioxin levels in human tissues. Am J of Pub Health 85, 516-522.
5. Schecter A, Fürst A, Päpke O, Samedy M, Piskac AM. (2001) Levels of dioxin and dibenzofuran

congeners in food and blood from Cambodia, Dioxin 2001, Gyeongju, Korea, Organohalogen Compounds, Vol. 52, 260-264; Ed., Jae-Ho Yang, Catholic University of Daegu, Korea.
6. Schecter A, Fürst P, and Päpke O. (1991) Dioxins, dibenzofurans and chlorinated organic compounds in human milk and blood from Cambodia, Germany, Thailand, USA, USSR and Vietnam. Chemosphere 23, 1903-1912.
7. Malisch R, Bruns-Weller E, Knoll A, Fürst P, Mayer R, and Wiesmuller T. (2000) Results of an "emergency quality control study" as confirmation of a PCDD/PCDF-contamination of milk and butter samples. Chemosphere 40, 1033-40.
8. Ryan JJ, and Mills P. (1997) Lipid extraction from blood and biological samples and concentrations of dioxin-like compounds. Chemosphere 34, 999-1009.
9. Schecter A, Cramer P, Boggess K, and Olson J. (1997) Levels of dioxins, dibenzofurans, DDE, and PCB congeners in pooled food samples collected at supermarkets across the United States. Chemosphere 34, 1437-1447.
10. NATO. (1988) International toxicity equivalency factors (I-TEF) method of risk assessment for complex mixtures of dioxins and related compounds. Report No. 176, Brussels, Belgium.
11. Malisch R. (1998) Update of PCDD/PCDF-intake from food in Germany. Chemosphere 37, 1687-1698.
12. Schecter A, Cramer P, Boggess K, Stanley J, Päpke O, Olson J, Silver A, and Schmitz M. (2001) Intake of dioxins and related compounds from food in the U.S. population. J Toxicol Environ Health 63, 1-18.
13. Schecter A, Dai LC, Päpke O, Prange J, Constable JD, Matsuda M, Thao VD, and Piskac AL. (2001) Recent dioxin contamination from Agent Orange in residents of a southern Vietnam city. J Occup Environ Med 43, 435-443.
14. Schecter A, Pavuk M, Constable JD, Dai LC, and Päpke O. (2002) A follow-up: high level of dioxin contamination in Vietnamese from Agent Orange, three decades after the end of spraying. J Occup Environ Med. 44, 218-220.
15. Van den Berg M, Birnbaum L, Bosveld AT, Brunstrom B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy SW, Kubiak T, Larsen JC, van Leeuwen FX, Liem AK, Nolt C, Peterson RE, Poellinger L, Safe S, Schrenk D, Tillitt D, Tysklind M, Younes M, Waern F, and Zacharewski T. (1998) Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106, 775-792.

**Table 1.** Exported Vietnamese food purchased in California, Texas, USA and Laos, 2001, ppt wet weight and WHO TEQs.[15]

| | Fat % | TCDD | Total PCDD | Total PCDF | Total co-PCB | TEQ PCDD | TEQ PCDF | TEQ PCDD/F | TEQ co-PCB | TOTAL TEQ |
|---|---|---|---|---|---|---|---|---|---|---|
| Vietnam Food Laboratory of J.J. Ryan | | | | | | | | | | |
| White Shrimp | 1.2 | 0.053 | 0.691 | 2.555 | 2.383 | 0.101 | 0.340 | **0.442** | 0.048 | 0.490 |
| Keo Fish | 0.6 | 0.001 | 0.015 | 0.056 | 0.009 | 0.002 | 0.007 | **0.009** | 0.000 | 0.009 |
| Apple Snail Meat | 0.9 | 0.002 | 0.039 | 0.021 | 0.012 | 0.003 | 0.000 | **0.003** | 0.000 | 0.003 |
| Frog Legs | 0.4 | 0.001 | 0.046 | 0.028 | 0.023 | 0.002 | 0.003 | **0.005** | 0.001 | 0.006 |
| Eel | 1.3 | 0.004 | 0.261 | 0.061 | 0.261 | 0.027 | 0.008 | **0.036** | 0.005 | 0.041 |
| Cat Fish | 9.0 | 0.010 | 0.830 | 0.135 | 1.117 | 0.047 | 0.023 | **0.071** | 0.020 | 0.091 |
| Baby Mud Fish | 0.4 | 0.011 | 0.048 | 0.246 | 0.169 | 0.020 | 0.039 | **0.059** | 0.011 | 0.070 |
| Black Anchovy Fish | 0.5 | 0.003 | 0.080 | 0.046 | 0.319 | 0.015 | 0.006 | **0.022** | 0.003 | 0.024 |
| Spiny Fish | 2.1 | 0.036 | 1.477 | 1.749 | 1.772 | 0.139 | 0.189 | **0.328** | 0.019 | 0.347 |
| Bombay Duck Fish | 0.9 | 0.012 | 0.243 | 0.060 | 1.304 | 0.052 | 0.011 | **0.063** | 0.046 | 0.109 |
| Vietnam Dried Fish* | 4.1 | 0.029 | 2.182 | 0.433 | 24.36 | 0.081 | 0.067 | **0.148** | 0.587 | 0.736 |
| Fish Paste* | 1.5 | 0.037 | 2.758 | 0.234 | 1.643 | 0.002 | 0.008 | **0.010** | 0.031 | 0.040 |
| Chicken Eggs* | 10.5 | 0.002 | 0.219 | 0.102 | 0.567 | 0.006 | 0.012 | **0.018** | 0.009 | 0.027 |
| Laboratory of R. Malisch | | | | | | | | | | |
| **Kinh Fish** | **1.6** | **0.009** | **0.589** | **0.104** | | **0.051** | **0.014** | 0.065 | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Spiny Eel | 4.7 | 0.010 | 1.189 | 0.276 | | 0.054 | 0.035 | **0.089** | | |
| Mackerel Fish | 1.1 | 0.004 | 0.243 | 0.067 | | 0.021 | 0.012 | **0.033** | | |
| Frozen Seagoby | 0.4 | 0.060 | 0.556 | 1.047 | | 0.096 | 0.164 | **0.260** | | |
| Gourami | 12.5 | 0.068 | 2.581 | 2.730 | | 0.124 | 0.329 | **0.453** | | |
| Anchovi Fish Rasbora | 11.0 | 0.033 | 1.663 | 0.466 | | 0.103 | 0.062 | **0.164** | | |
| Silure Fish Fillet | 1.1 | 0.005 | 0.796 | 0.089 | | 0.010 | 0.010 | **0.020** | | |
| Fresh Water Shrimp | 0.3 | 0.053 | 0.473 | 0.580 | | 0.076 | 0.081 | **0.157** | | |
| Fresh Water Prawn | 0.4 | 0.005 | 0.292 | 0.087 | | 0.012 | 0.011 | **0.023** | | |
| US Fish (for comparison)[9] | | | | | | | | | | |
| Ocean Fish | 1.4 | 0.030 | 1.300 | 2.300 | 92.52 | 0.130 | 0.144 | **0.274** | 0.094 | 0.368 |
| Fresh Water Fish | 4.8 | 0.150 | 10.200 | 6.000 | 527.73 | 0.473 | 0.340 | **0.813** | 0.365 | 1.178 |
| Halibut | 2.1 | 0.002 | 0.592 | 0.432 | | 0.003 | 0.027 | **0.030** | | |
| Cat Fish Filet | 20.0 | 0.080 | 14.940 | 0.250 | | 0.405 | 0.033 | **0.438** | | |
| Salmon Steak | 16.0 | 0.020 | 0.800 | 0.125 | | 0.034 | 0.017 | **0.051** | | |
| Shrimp | 0.5 | 0.020 | 2.320 | 0.130 | | 0.125 | 0.019 | **0.144** | | |

* Vietnamese food purchased in Laos. Total PCDD and PCDF refers to 2,3,7,8-substituted congeners, only. Total co-PCB refers to coplanar PCBs congeners 77, 81, 126 and 169. Total TEQ is the sum from PCDD/F-TEQ and co-PCB-TEQ (without mono-ortho PCB-TEQ).

**Table 2.** Laotian food from Vientiane and Sepone markets, ppt wet weight and WHO TEQs[15]

| | Fat % | TCDD | Total PCDD | Total PCDF | Total co-PCB | TEQ PCDD | TEQ PCDF | TEQ PCDD/F | TEQ co-PCB | TOTAL TEQ |
|---|---|---|---|---|---|---|---|---|---|---|
| Laboratory of J. J. Ryan | | | | | | | | | | |
| Dried White Fish – V | 10.6 | 0.005 | 0.369 | 0.150 | 2.750 | 0.031 | 0.014 | **0.045** | 0.047 | 0.092 |
| Duck Eggs – S | 13.0 | 0.029 | 1.771 | 0.470 | 3.516 | 0.084 | 0.060 | **0.144** | 0.067 | 0.210 |
| Large Carp A Liver – S | 6.1 | 0.329 | 6.739 | 1.554 | 4.489 | 0.604 | 0.131 | **0.735** | 0.116 | 0.851 |
| Large Carp A Eggs – S | 5.4 | 0.137 | 0.868 | 0.224 | 1.893 | 0.208 | 0.030 | **0.238** | 0.043 | 0.281 |
| Fish (flesh) – S | 0.5 | 0.005 | 0.105 | 0.090 | 0.061 | 0.001 | 0.004 | **0.005** | 0.004 | 0.009 |
| White Carp (flesh) – S | 2.5 | 0.028 | 0.673 | 0.172 | 0.789 | 0.053 | 0.020 | **0.073** | 0.020 | 0.093 |
| Catfish (flesh) – S | 2.4 | 0.040 | 1.803 | 0.215 | 1.038 | 0.109 | 0.033 | **0.142** | 0.037 | 0.179 |
| Catfish (liver) – S | 5.4 | 0.198 | 9.735 | 2.271 | 5.220 | 0.259 | 0.131 | **0.391** | 0.167 | 0.558 |
| White Carp (fat) – S | 53.7 | 0.475 | 5.930 | 3.388 | 19.277 | 0.985 | 0.384 | **1.369** | 0.533 | 1.902 |
| Catfish (fat) – S | 84.4 | 2.432 | 74.63 | 8.816 | 54.974 | 5.537 | 1.449 | **6.986** | 2.039 | 9.025 |
| Laboratory of R. Malisch | | | | | | | | | | |
| Malkina catfish – V | 10.1 | 0.012 | 1.321 | 0.550 | 1.439 | 0.177 | 0.077 | **0.254** | 0.036 | 0.290 |
| Carp (flesh) – V | 18.9 | 0.047 | 1.409 | 2.173 | 3.943 | 0.183 | 0.261 | **0.444** | 0.093 | 0.537 |
| Carp (liver) – V | 14.0 | 0.021 | 1.116 | 1.542 | 2.612 | 0.119 | 0.201 | **0.320** | 0.064 | 0.384 |
| Dried fish – V | 10.9 | 0.019 | 1.034 | 0.305 | 2.698 | 0.119 | 0.028 | **0.147** | 0.047 | 0.194 |
| Eel – V | 0.5 | 0.006 | 0.288 | 0.071 | 0.289 | 0.016 | 0.003 | **0.020** | 0.003 | 0.022 |
| Mekong fish – V | 1.7 | 0.013 | 1.126 | 0.355 | 3.474 | 0.084 | 0.040 | **0.125** | 0.151 | 0.276 |
| Pork liver – V | 4.0 | 0.004 | 3.954 | 0.372 | 0.617 | 0.017 | 0.048 | **0.065** | 0.012 | 0.077 |
| Buffalo liver – V | 5.0 | 0.004 | 3.593 | 0.083 | 0.932 | 0.013 | 0.010 | **0.024** | 0.007 | 0.031 |
| Beef – V | 13.0 | 0.008 | 0.826 | 0.163 | 1.159 | 0.040 | 0.033 | **0.074** | 0.050 | 0.123 |
| Pork sausage – V | 41.9 | 0.000 | 1.860 | 0.160 | 1.205 | 0.039 | 0.028 | **0.067** | 0.024 | 0.091 |
| Pork – V | 37.6 | 0.000 | 1.890 | 0.090 | 0.663 | 0.023 | 0.016 | **0.039** | 0.009 | 0.048 |
| Lao chicken – V | 5.1 | 0.013 | 0.612 | 0.159 | 2.263 | 0.045 | 0.022 | **0.067** | 0.048 | 0.115 |
| Duck eggs – V | 14.9 | 0.011 | 68.97 | 0.284 | 1.053 | 0.090 | 0.033 | **0.124** | 0.023 | 0.146 |
| Fish sauce and fish – S | 9.6 | 0.213 | 7.170 | 0.726 | 4.264 | 0.551 | 0.102 | **0.653** | 0.152 | 0.805 |
| Chicken liver – S | 0.8 | 0.007 | 6.891 | 0.148 | 0.379 | 0.035 | 0.014 | **0.048** | 0.010 | 0.058 |
| Pork liver – S | 3.7 | 0.070 | 314.5 | 1.153 | 0.935 | 0.323 | 0.123 | **0.446** | 0.041 | 0.488 |
| Beef – S | 2.7 | 0.009 | 0.166 | 0.026 | 0.161 | 0.012 | 0.003 | **0.015** | 0.004 | 0.019 |
| Sepone deer – S | 0.5 | 0.001 | 0.083 | 0.010 | 3.143 | 0.001 | 0.001 | **0.002** | 0.031 | 0.033 |

S – Sepone Village and District Center (sprayed), V –Vientiane city (non-sprayed).
Total PCDD and PCDF refers to 2,3,7,8-substituted congeners, only. Total co-PCB refers to coplanar PCBs congeners 77, 81, 126 and 169. . Total TEQ is the sum from PCDD/F-TEQ and co-PCB-TEQ (without mono-ortho PCB-TEQ).